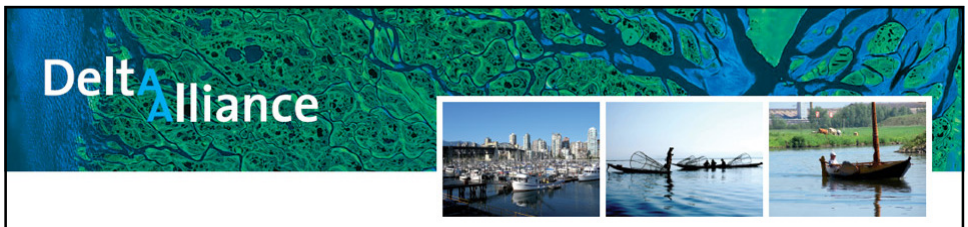


The Rhine-Meuse delta, the Netherlands

An overview of delta issues

Cees van de Guchte *(Deltares)* &

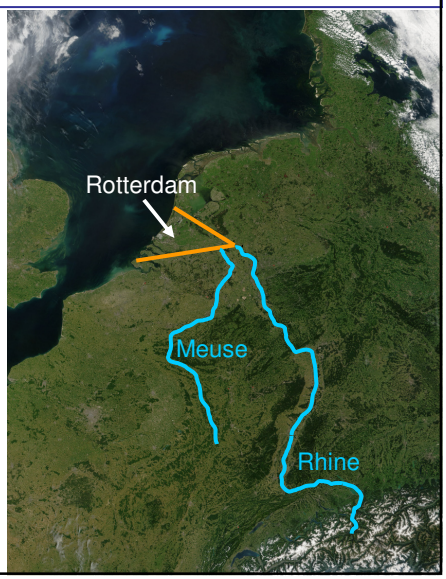
Bart Makaske *(Alterra, Wageningen UR)*

Knowledge for Climate

Conference *Deltas in times of climate change*, Rotterdam, the Netherlands, 29 September 2010

General characteristics

- **Rhine-Meuse delta plain area:** ~7500 km²; large parts below sea level (down to -6 m)
- **Mean annual discharge:** Rhine 2300 m³/s; Meuse 230 m³/s
- **Catchment area:** Rhine 185,000 km²; Meuse 36,000 km²
- **Holocene delta deposits:** ≤15 m thick (extensive peat beds)
- **Flood protection:** coastal dunes, dams and dikes
- **Population:** ~6,5 million
- **Infrastructure:** Europe's largest seaport (Rotterdam) and fourth largest airport (Schiphol)

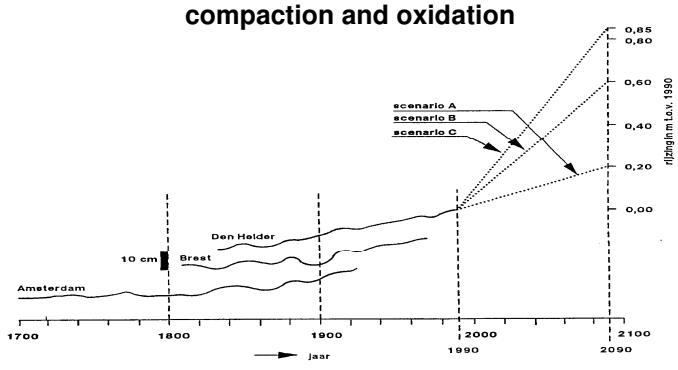


Drivers of change (1)

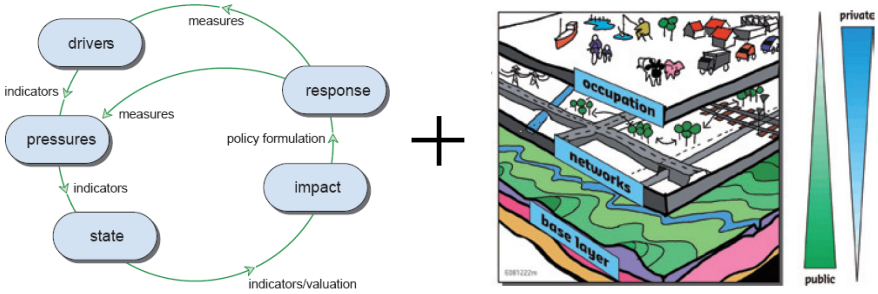
- **Demographic trends –** minor growth of population
- **Economic developments –** GDP/capita US$ ~30,000; 97% of working population employed in services and industry; expanding knowledge-intensive industry
- **Technological developments –** research institutes for 'delta technology'; many academic and research programs in hydraulic engineering and water management at universities

Drivers of change (2)

- **Climate change –** higher peak river discharges (winter)
  long drought periods (summer)
  sea-level rise ≤ 0.65 to 1.3 m in 2100
- **Subsidence –** Tectonic subsidence ~10 cm/century
  ≤10 mm/year surface-lowering due to peat compaction and oxidation



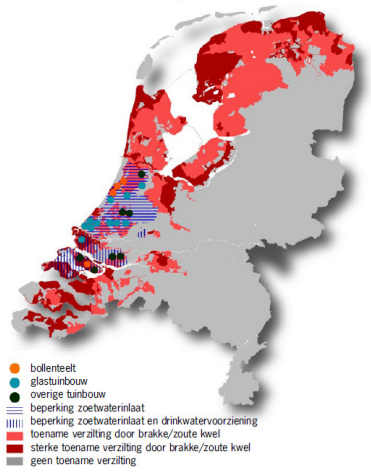
Approach



Pressures – occupation layer

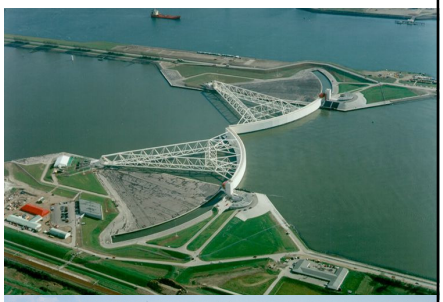
- **Demographic trends – population density ~500 inhabitants/km²; high pressure on space**
- **Vulnerability to flooding – safety levels: 1/1250 (river dikes) to 1/10,000 years (coastal defense); sea-level rise, river run-off and growing investments will increase flood risk**
- **Freshwater shortage – rising sea levels will increase salt water seepage and will cause local freshwater shortages**

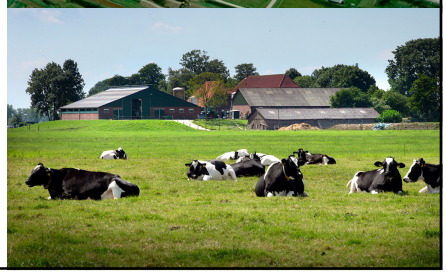
Salinisation and agriculture



Pressures – network & base layers

- **Flood protection infrastructure – adaptation to climate change requires 1.2 to 1.6 billion €/year until 2050**
- **Coastal erosion – stable coastline (due to dikes, dams and beach nourishment); increased maintenance needed**
- **Biodiversity – Gradual deterioration of estuarine and coastal ecosystems (pollution and reduced hydrodynamics); extensive riverine nature restoration projects**





Governance issues

- **Governmental cooperation – governmental 'Delta Commission' has drafted a long-term vision for delta management (more sustainability, while maintaining/upgrading safety levels)**
- **Cooperation between government and private sector – many Public-Private Partnerships in the fields of infrastructure, housing and coastal defense**
- **Involvement of stakeholders and citizens – procured by laws and legal instruments; many NGOs are influencing policy and implementation of plans**
- **Approaches for dealing with risks and uncertainties – growing attention for flood risk awareness-raising, implementation of more resilient flood risk management strategies, and early-warning and recovery programs**

Score card for the Rhine-Meuse delta

	Land and water use (occupation layer	Infrastructure (network layer)	Natural resources (base layer)	Governance	Overall Resilience & Sustainability index
Current situation 2010	+	++	+	+	+
Scenario 1 moderate 2050	0	++	0	+	0/+
Scenario 2 extreme 2050	-	++	-	+	0

resilience/sustainability: *+ (good), ++(very good), 0 (medium),- (low), -- (very low)*

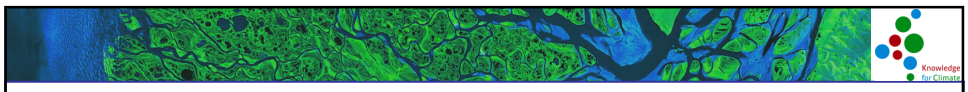
Knowledge gaps (1)

Occupation layer

- **How can we optimally integrate the water management and flood safety infrastructure into spatial planning concepts?**
- **Which innovations are needed in industry and agriculture for more efficient water use?**

Network layer

- **How should future levees be designed in order to raise safety standards 10 times?**
- **How can dams and storm surge barriers in estuaries and river mouths be designed in order to guarantee safety, while minimally disturbing natural processes and navigation?**



Knowledge gaps (2)

Base layer

- How can we use natural processes for land reclamation and sustainable delta management?
- Which morphological and ecological changes are currently occurring and are their rates changing?
- What is the magnitude of sea-level rise and increased peak discharges and what is the prediction uncertainty?

Governance

- How should the costs of water and water treatment in future times of scarcity be priced for users?
- How should roles and responsibilities in delta management be organized in the future, in order to guarantee flood safety in a cost-effective way?
- Which financial arrangements should be made for future flood protection and for compensation of large-scale flood damage?